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GEOECOLOGICAL EVALUATION OF BELGRADE AND ENVIRONMENT FOR THE PURPOSES OF REST AND RECREATION

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ABSTRACT

With this work we want to affirm geoecological evaluation, planning and landscape management. Geoecological evaluation of the Belgrade region, for the purpose of rest and recreation, was performed with quantitative method of diversity (V-Wert Methode) of Hans Kiemstedt. The method is suitable for the determination of potential locations suitable for rest and recreation, with various forms of relief (edge of forest and water, then climate and relief). Due to the surface of the evaluated area and the amount of data that had to be processed, the benefits of geographic information systems are expressed. According to this geoecological analysis favorable and very favorable areas for recreation are tied exclusively to the river flows of Sava and Danube. Each of the four raster units, which are marked as very favorable for recreation, include items of river islands (Baric river island, River island Ciganlija, River island Grocanska, Batkov river island and River island Brestovacka), which have high values of the length of the edges of the water.

Key words: *kiemstedt, method of diversity, geoecology, recreation, Belgrade and environment, GIS*

INTRODUCTION

Air pollution, noise and accelerated rhythm of life and work are causing a range of pathological conditions in the urban population. The healthiest, most natural and most convenient way to improve impaired health is to spend time in nature. In the fresh air are realized optimal conditions for recreation, which through an active rest, allows recovery and refreshments. All elements of recreation are interconnected and make a unique system, which favorably affects the renewal of work and life abilities of humans. By using the appropriate methodologies for valorization, with the help of information technology, it is possible to estimating suitability of space for different needs.

METHODOLOGY OF THE RESEARCH

The subject of this paper is geoecological evaluation of the wider area of Belgrade in order to evaluate benefits of given space for recreation [1]. During the geoecological evaluation of the Belgrade region was used quantitative method of diversity (V-Wert Methode), Hans Kiemstedt, which is supplemented and tailored to the researched area [2,3]. Model was first presendet in 1967 in a doctoral dissertation of a professor of the Hannover University, Hans Kiemstedt. It is based on knowledge of the natural elements

and is suitable for evaluating the landscape for recreation. Evaluation of the field based on this method is most suitable for landscapes with various forms of relief, or for mountainous areas [2,3,4,5].

We tested Kiemstedt method during geoecological evaluation of Banj Hill (Sehitluci) near Banja Luka, where it showed fair results [6,7,8,9]. Purpose of the work was to make a synthesis map of capabilities for recreation based on the analysis of collected data. Based on the established criteria Hans Kiemstedt defined a formula for calculating the amenities of recreation surfaces:

$$V = \frac{W + G * 3 + R + N}{1000} * K$$

where is:

W – edges of forests
G – edges of water
R – energy of relief
N – way of use
K – climate factor.

CASE STUDY, CITY BELGRADE

Belgrade city covers an area of 3,222 km^2, Figure 1. In 17 urban and suburban municipalities live 1.659.440 people [10]. At the contact of plains and low mountains, and at the place where is the estuary of two important and major rivers, Belgrade is among the cities with the best geographic position in Europe. Belgrade's surroundings consist of two different environments, Pannonian Plain on the north, under wheat and maize, and Sumadija on the south of the Sava and Danube rivers, under orchards and vineyards. Highest relief forms in Sumadija are low mountain Kosmaj (628 m) and the volcanic cone Avala (511 m). The terrain from the south, gradually descends to the north, Figure 1. Belgrade and environment climate mostly has modern – continental characteristics. The average annual air temperature is 11,7ºC. In the area of Belgrade and its environment average annual precipitation is 669.5 mm of rainfall [11].

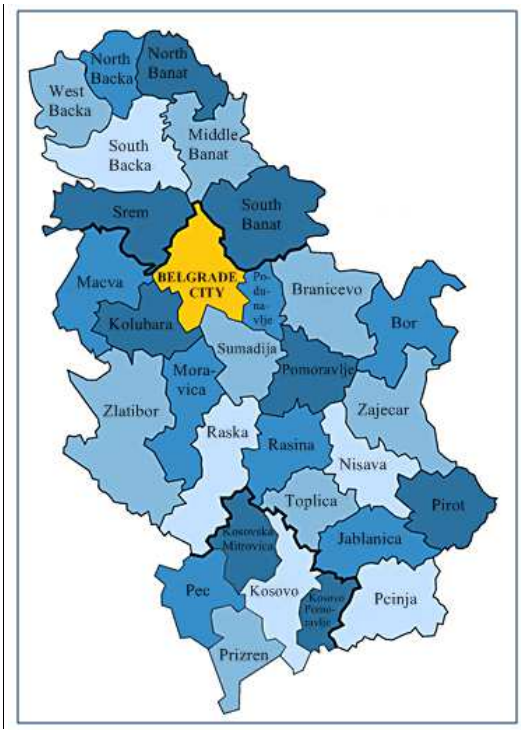

Figure 1. The position of Belgrade city within the Republic of Serbia

For the purposes of the research presented in this paper was used GIS software GeoMediaProfessional, where is carried out the analysis through the evaluation of the area by all criteria set out in the model of Hans Kiemstedt and overlapping layers of data in order to obtain synthesis map of amenities of area for recreation, which is the purpose of this research. At the beginning was created a network of GRID cells dimensions of 1x1 km, so for each of so obtained areas could be calculated suitability for recreation in relation to each of the criteria.

EDGES OF FORESTS AND WATER

Edges of forests and water were chosen because they have a positive impact on the senses of the observer. Kiemstedt emphasizes the importance of the edges of water, because according to many authors water enriches space making it more diverse and more suitable for recreation.

The first criteria that is evaluated for the purpose of assessing benefits of the Belgrade region and its environment for recreation represent the length of the edge of forest. For this purpose was used Corine Land Cover database of landuse for the year 2012 [12], Figure 2. From total base (44 classes of land use) were singled out classes that include deciduous, coniferous and mixed forests, and then was calculated how many of these previously mentioned GRID cells contain edges of forests in meters.

Figure 2. Promenade on Ciganlija river island with a view to The Ada Bridge in the background
Source: http://www.serbia.com/

The lengths of the edges of water, as well as other criteria of this analysis were obtained in the same manner as described in the above criteria, except that this time were separated and analyzed standing and running water, ie the length of their banks for each GRID cell. That way is obtained information on the length of the coast at km^2 for the entire surface of the studied area.

ENERGY OF RELIEF

As the energy of the relief represents the difference between the highest and the lowest point in meters in each of the isolated GRID cell, for the purposes of evaluation of the surface by this criteria, it is necessary to use data from a digital elevation model – DEM [13,14], Map 1. Based on the calculated relative difference in altitude, each raster unit is determined by points that are assigned to those units, Table 1.

Table 1. Scale of relief values

Altitude difference (m)	Values of the relief
10-20	220
20-30	300
30-60	400
60-100	590
100-250	860
250-500	1200

WAY OF USE

In order to evaluate the surface based on usage patterns, for purposes of recreation, re-used were data provided by the database Corina. To every surface of the above mentioned database, according to its intended use, was assigned an adequate number of points in relation to its suitability for recreation, and then calculated the percentage share for each of the surfaces in each square of the raster.

The values obtained are multiplied by the corresponding weighting factor, Table 2, and then all the values on the surface of each cell, are added and give the total number of points that reflects the affordability of surfaces according to this criteria [15].

Table 2. Weight factors for each purpose of area

Type of use		Weight factors
Cultivated fields and gardens		6
Meadows and pastures		15
Orchards and vineyards		8
Forests		19
Heath		21
Ponds		12
Swamps		10
Infertile land		21
Waters:	Rivers	50
	Lakes	50
	Streams	20
	Canals(main)	10

CLIMATE FACTOR

Climate factor is determined based on data of annual temperatures and precipitation, taking into account the altitude and type of landscape. Kiemstedt gave values of this factor based on different landscapes of Germany [9], Table 3.

Table 3. Weight factors of climate types

Climate type	Weight factors
Urban climate	0,65 - 0,80
Climate of basin	0,70 - 0,90
Climate of North - Germany lowland	0,90 - 1,10
Coastal climate (Baltic and North Sea)	1,30 - 1,60
Climate of sub mountainous zone	1,10 - 1,20
Climate of mountainous zone	1,20 - 1,40
Climate of high mountains	1,30 - 1,50
Climate of central Alps	1,30 - 1,80

Rating was done based on data of temperature, rainfall and dominant winds on which were estimated these types of climate in the table 3. Points for climate factor are assigned primarily based on altitude for what were once again used data from a digital elevation model. Problem of using Kiemstedt application model is that the points for this criteria are only for the territory of Germany. Therefore to the lowland areas in the northern part of the Belgrade city are assigned points that correspond to the "North German Plain," and since, according to Kiemstedt model, are given special classes for climate of high mountains and climate of the Central Alps, the highest parts of the mountains Avala and Kosmaj were evaluated with points for the mountain climate zone. To areas between previously mentioned bands are assigned values for the sub mountain climate zone and populated areas are valued with points corresponding to the areas with the urban climate.

CATEGORIES OF DIVERSITY AND MAKING SYNTHETIC MAPS OF RECREATION BENEFITS

For each of these criteria was given a thematic map, which contains the corresponding attribute data with the points for each of the criteria that it represents. By "overlapping" all of received maps it is possible to carry out various operations with their attributes, and so given attributes are used based on provided formula to get the final points that indicate the suitability of the Belgrade city for the purpose of recreation Map 2,3.

Since each raster unit, whose entire surface or part of the territory of Belgrade city, included in evaluation, presented data include slightly larger area than the area mentioned of administrative units, more precisely 3.487 km^2 opposite 3.222 km^2 in favor of the total analyzed surface.

Taking into consideration all criteria of Hans Kiemstedt model, their evaluation and summing according to the above formula, the obtained results are classified into one of four classes of benefits of area for recreation, Table 4. Benefits for the given purpose, the surface of Belgrade city are divided as follows [2,14,15]:

- Unfavorable surfaces – 2939 km^2 – 8 4,3%;
- Conditionally favorable – 500 km^2 – 14,3%;
- Favorable – 44 km^2 – 1,3%;
- Very favorable – 4 km^2 – 0,1%.

Table 4. Categories of diversity by Kiemstedt

Categories	Classes	Span
I	Unfavorable	V < 3,72
II	Conditionally favorable	3,72 < V < 7,44
III	Favorable	7,44 < V < 11,16
IV	Very favorable	V > 11,16

Unfavorable surfaces are distributed throughout the entire evaluated area and mainly include populated areas away from watercourses. Conditionally favorable surfaces are distributed along the Sava and Danube rivers, which contributes length of the edges of the water, and in the forested central part of Belgrade city, because of great length of the edge of the forest. Also are recognized parts that occupy the mountains Avala and Kosmaj, on what mostly affected points obtained on the difference between the highest and lowest values of altitude, ie relief energy criteria.

Favorable and very favorable areas for recreation, according to this analysis, are related exclusively to the river Sava and Danube flows, because of the great importance given to the criteria of the length of the edges of the water, and that best reflects the interest that each of the 4 raster units is marked as very favorable for recreation, and includes part of the area of some river island, because in that case the values of the length of the edge of the water are very high. Those are downstream: Baric river island, River island Ciganlija, River island Grocanska, Batkov river island and River island

Brestovacka. The last three are located near the village of Grocka, and parts of Grocanska and Batkov river ada are along included in one raster unit with the epithet of very favorable for recreation.

CONCLUSION

During the drafting of this work came to the fore the advantages provided by the application of geographic information systems. Without the use of modern GIS tools, considering the surface of the evaluated areas and a tremendous amount, the evaluation of this region for recreational purposes would be very difficult to do. The quality of input data can be relative, but their processing through GIS is absolutely correct, which is an advantage when evaluating the landscape for recreation.

The advantage of using Hans Kiemstedt model, when evaluating landscapes for the needs of rest and recreation, is in the fact that it includes all the criteria that are relevant and that can be quantified. When determining ideal location for rest and recreation, regardless of its deficiencies, it can be taken into account a subjective evaluation. However, it should keep in mind that the subjective evaluation of the functioning area, depending on its size, requires a lot of time. Also, since it is a subjective evaluation, the results will depend directly on the affinity of analysts, which for all users of the area may not be accepted as relevant. The advantage of Kiemstedt model is that it precisely determines the potential locations suitable for recreation, from which you can choose the one that is best suited to the subjective assessment. Such combination is correct.

The main disadvantage of this method is that the value criteria is limited to raster unit. For example, in calculating the energy of relief to a particular location on the edge of raster units, it will not be considered the value of the mountain peak, which is located on the other side of the border that divides the two raster units, all values will be discussed within the unit, regardless of whether they are farther from mentioned peak or not.

Each of the four most suitable locations for recreation is undoubtedly very attractive for this purpose. The area around Baric river island has not been yet adequately exploited, but certainly there is a great potential, considering the value that this area possesses. The area around the Grocanska river island is decorated with promenade, sports grounds and restaurants.

River island Ciganlija has lots of greenery, sports facilities, restaurants, bathing and secondly, is the most attractive region for recreation of inhabitants of Belgrade. Considering the fact that according to the analysis completed this area is placed in class that is most suitable for recreation, it is clear that obtained results are of excellent quality and the Hansa Kiemstedt method is very good for determining the optimal landscape for purposes of recreation possibilities. Kiemstedt model can be used for geoecological evaluation of landscapes in our country, with note that the climate factor must be considered carefully and used for areas that are of similar characteristics as it is at Kiemstedt. Therefore, we suggest that when evaluating climate factors is used bioclimatic references that are made on the basis of daily values by model and specification of Krištof Blažejčuk (Meneks _05).

For this occasion we have used bioclimatic model for Belgrade in July 2014, on the basis of which was carried out classification of weather types.

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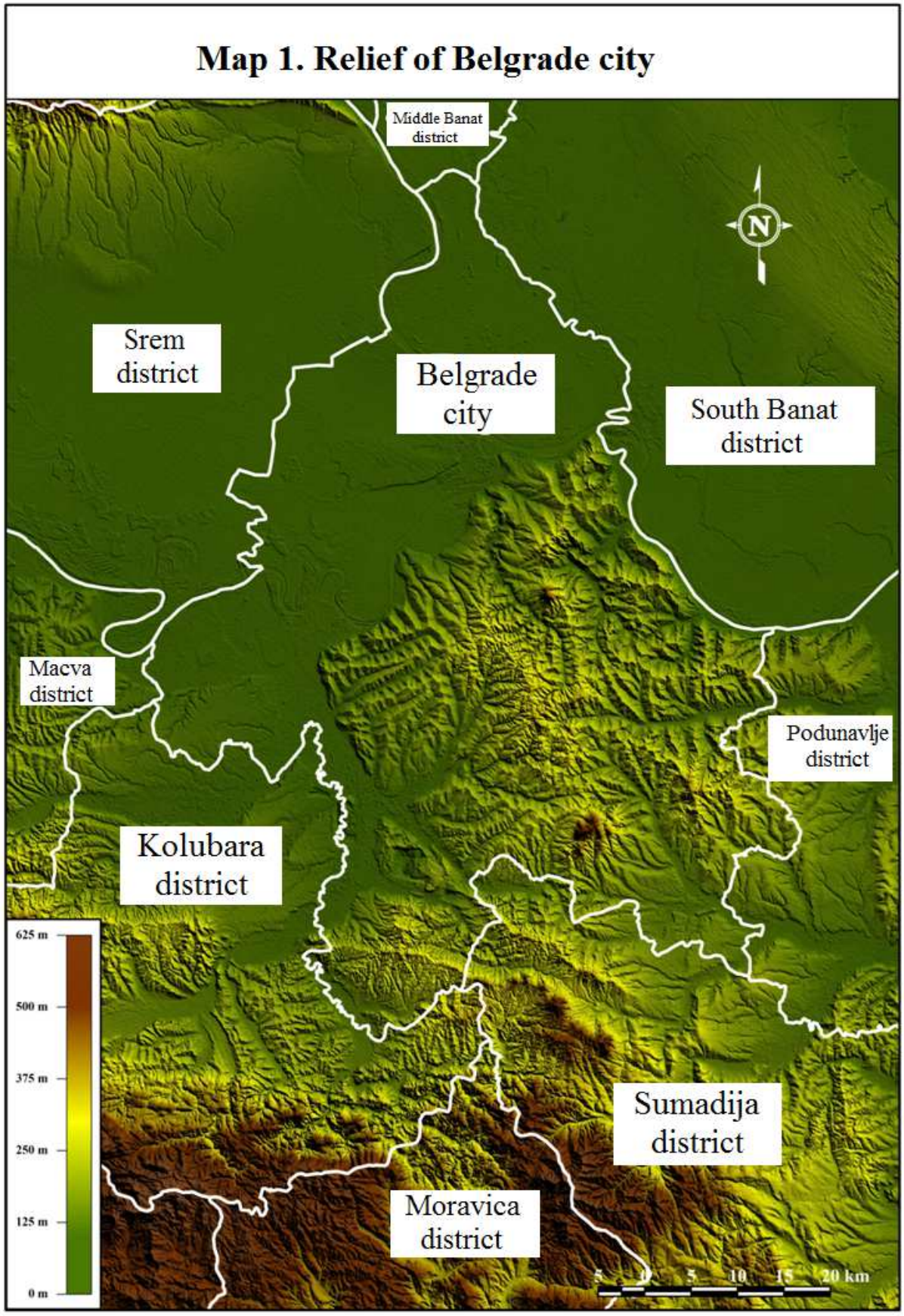
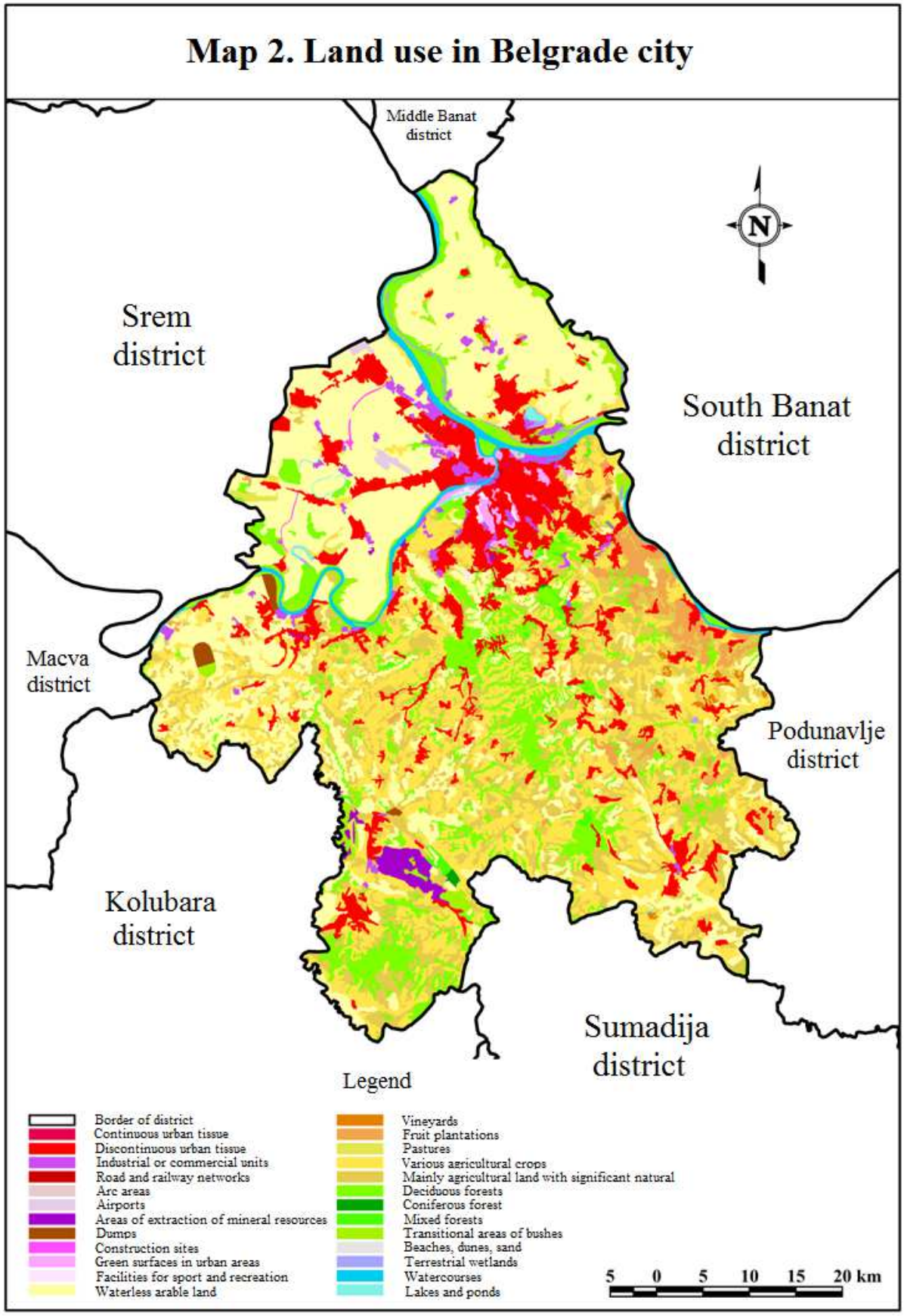
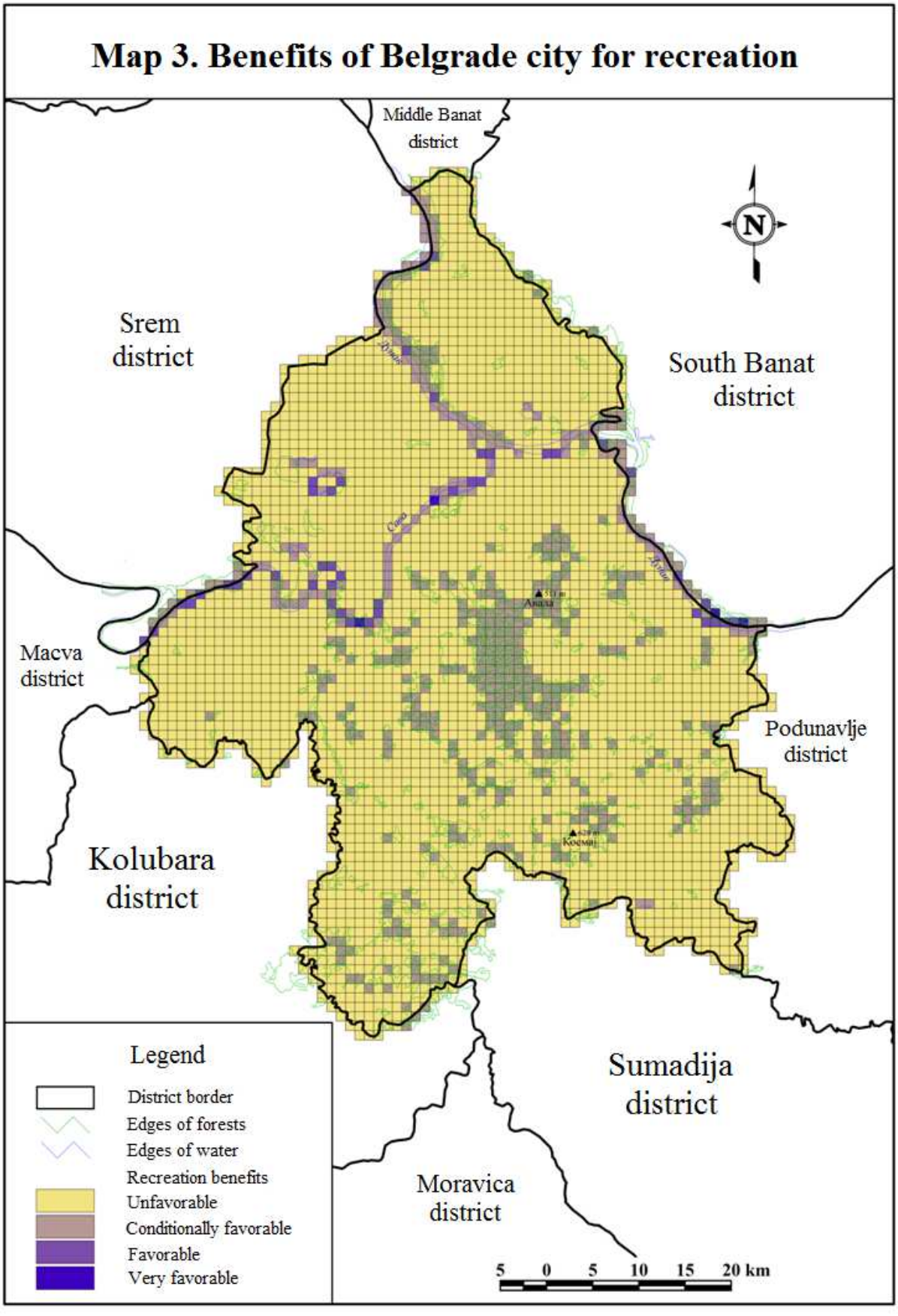
Annexes:

Map 1. Relief of Belgrade city
Map 2. Land use of Belgrade city
Map 3. Benefits of Belgrade city for recreation


Map 1. Relief of Belgrade city
Middle Banat district
N
Srem district
Belgrade city
South Banat district
Macva district
Podunavlje district
Kolubara district
Sumadija district
Moravica district
625 m
500 m
375 m
250 m
125 m
0 m
5 0 5 10 15 20 km


Map 2. Land use in Belgrade city
Middle Banat district
N
Srem district
South Banat district
Macva district
Podunavlje district
Kolubara district
Sumadija district
Legend
Border of district
Continuous urban tissue
Discontinuous urban tissue
Industrial or commercial units
Road and railway networks
Arc areas
Airports
Areas of extraction of mineral resources
Dumps
Construction sites
Green surfaces in urban areas
Facilities for sport and recreation
Waterless arable land
Vineyards
Fruit plantations
Pastures
Various agricultural crops
Mainly agricultural land with significant natural
Deciduous forests
Coniferous forest
Mixed forests
Transitional areas of bushes
Beaches, dunes, sand
Terrestrial wetlands
Watercourses
Lakes and ponds
5 0 5 10 15 20 km


Map 3. Benefits of Belgrade city for recreation
Middle Banat district
N
Srem district
South Banat district
Macva district
Podunavlje district
Kolubara district
Sumadija district
Moravica district
Legend
District border
Edges of forests
Edges of water
Recreation benefits
Unfavorable
Conditionally favorable
Favorable
Very favorable
5 0 5 10 15 20 km